

Effect of Open Heart Surgery on Lung Complications with their Incidence and Fate – a Single Center Study

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Abstract :

This prospective study was designed to determine the incidence of pulmonary complications after open cardiac surgery as well as to identify predisposing factors of these complications at NICVD, Dhaka, Bangladesh. The cumulative incidence of pulmonary complications after open heart surgery was 16.85% (15 of 89) with a mortality rate of 33.33% (5 of 15) and the overall mortality among all patients was 5.62% (5 of 89). Pulmonary complications occurred in 15.9% of patients with coronary artery revascularization, 11.53% in patients with valvular

replacement and 26.31% in patients with congenital heart disease.

ARDS occurred in 2.25% of patients with a mortality rate of about 100%, pneumonia in 5.62%, atelectasis in 2.25%, pleural effusion in 5.62% and pneumothorax in 3.37%. The most predisposing factors were massive blood transfusion, re-exploration for control of post-operative bleeding, cardiopulmonary resuscitation and prolonged length stay in the intensive care unit.

Keywords:

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Introduction:

The incidence of postoperative pulmonary complications (PPC) after open heart surgery varies from 6% to 70% depending upon the criteria used to define pulmonary complications¹. The various components of the respiratory system; airways, lungs, chest wall, intercostal muscles; diaphragm and neural pathways, to and from these various components are subjected to damage caused by a variety of processes associated with cardiac surgery and cardio pulmonary bypass (CPB). Popular believe is that general anesthesia, surgical incision, cardiopulmonary bypass (CPB), ischemia time, intensity of surgical manipulation and number of drains may predispose patients to pulmonary function changes, which are highly relevant on the onset of pulmonary complications in cardiac surgery postoperative Cardiac

surgery through either a sternotomy or thoracotomy has deleterious effects on the function of the muscle pump and the chest wall. Additionally, phrenic nerve damage resulting from cold topical solution applied inside the pericardium may cause mechanical problems. Left side cardiac distension or elevated pressure may cause alveolar edema, and transfusion reaction or allergic reaction to drugs (e.g. protamin) may increase capillary permeability leading to alveolar flooding. Mechanical alterations in lung function.²

(A) Atelectasis

It is the most common pulmonary complication after cardiac surgery occurring in about 70% of cases. During (CPB), the lungs are not perfused and they are allowed

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to collapse to functional residual capacity. When the lungs are subsequently re-expanded then variable degree of pulmonary atelectasis remains .

Etiology of pulmonary atelectasis

Preoperative factors : (1) Smoking, chronic bronchitis.(2) Obesity [decreased functional residual capacity (FRC)]. (3) Cardiogenic pulmonary edema.

(B) Acute lung injury [ARDS] and cardio-pulmonary by

Pass Activation of complement and neutrophils causes sequestration of neutrophils in the pulmonary microvasculature and an increase in the pulmonary capillary permeability .On the other hand reperfusion injury after ischemia generates oxygen free radicals and may also contribute to lipid peroxidationat this time . There is an increased systemic level of thromboxane during (CPB). Thromboxane released from platelets activated by extra corporeal circuit, and its profound effects on vasoconstriction and platelet aggregation could further injure the microcirculation .

(C) Postoperative pneumonia

Pneumonia remains the greatest threat to survival that exists in a surgical patient. Patients are often debilitated by the effects of the disease process, intravenous lines, bladder catheters, endotracheal tube and surgical wound. The incidence of pneumonia is about 5–19%. More than 90% of nosocomial pneumonia is bacterial and in 50–70% of cases the responsible organisms are gram negative bacilli. The most important causative gram negative organisms include Klebsiella species, Escherichia coli and Pseudomonas aeruginosa .2

Very few studies have focused on the intraoperative and postoperative risk factors responsible for the development of pulmonary complications in patients undergoing cardiac surgery using cardiopulmonary bypass. In present study we determined the frequency of post-operative pulmonary complications (PPCs) and inter-operative factors associated with PPCs in patients undergoing cardiac surgery using cardio-pulmonary bypass.3

Methods:

This prospective observational study was arranged in National Institute of cardiovascular Diseases Dhaka Bangladesh . A total number of 89 patients undergoing cardiac surgery using cardiopulmonary bypass (CPB) from Jan 2015 to August 2016 in a single cardiac surgical unit were included. Patients undergoing coronary artery bypass grafting (CABG) and valvular operations and

Patients undergoing congenital cardiac procedures were selected. In all patients standard procedures were used for surgery. All procedure was done through median skin incision. Standard cardiopulmonary bypass apparatus was used in all patients incorporating membrane oxygenator and arterial line filters. Venous cannulation was done through right atrium using either two single venous cannulas or a two stage single venous cannula. And arterial cannulation was done through ascending aorta using either angles tip or straight tip aortic perfusion cannula. Lactated ringer was used to prime CPB circuit. After establishing CPB, temperature was lowered to 30 to 28 degree Celsius to maintain moderate hypothermia during surgery. Cold blood cardioplegia was used to arrest and protect the heart of patients undergoing CABG and tepid blood cardioplegia was used for valvular procedures after application of aortic cross-clamp. All patients were weaned off from CPB after re-warming the patient to 36.5 to 37 degree Celsius. All patients were shifted to intensive care unit (ICU) in stable condition. And weaned off from mechanical ventilation in ICU. The senior anesthetist and the pulmonologist of the hospital noted data regarding postoperative pulmonary complications. Duration of mechanical ventilation > 48 hours or need for re-intubation of patients was considered as respiratory failure. Pneumonia was labeled by the presence of fever

and sputum along with presence of findings of pneumonia on chest X-rays and on laboratory reports weaned off from mechanical ventilation in ICU. The senior anesthetist and Any death during hospital stay or within one month after surgery due to the results of surgical complications was considered operative mortality. Data analysis was done using SPSS v23 software. Chi-square tests were used to determine the effect of post-operative pulmonary complications on operative mortality and to compare the frequency of PPCs in valvular and CABG patients. Logistic

regression analysis was used to determine the association of pre-operative and intra-operative variables on the incidence of PPCs after surgery. P-value d" 0.05 was taken as significant effect.

Results:

The study included 89 patients (65 males and 24 females) the average age was 41 years that ranged from 15 to 68 years. The patients were classified into three groups:

(1) Coronary artery revascularization includes 44 patients (36 males and 8 females with mean age of 51.9 years.

(2) Valve replacement includes 26 patients (18 males and 8 females) with mean age of 15–53 years. (3) Congenital heart disease includes 19 patients (11 males and 8 females) with mean age of 4.9 years.

The cumulative incidence of pulmonary complications after open heart surgery was 16.85% (15 of 89) with a mortality rate of 33.33% (5 of 15) and the overall mortality among all patients was 5.62% (5 of 89).

Acute respiratory distress syndrome (ARDS) developed in; one patient with congenital heart diseases, and 1 patient with coronary artery revascularization. The first patient with coronary artery revascularization presented with dyspnea, tachypnea, hypoxemia, and bilateral diffuse pulmonary infiltration. Mechanical ventilation was done, the patient underwent mechanical ventilation for 5 days with no response to supportive therapy and died due to multiorgan failure. ARDS occurred in a female patient 3 years old after closure of ventricular septal defect, after extubation by 8 h she developed tachypnea, hypoxemia, and diffuse pulmonary infiltrations, and intubation and mechanical ventilation was done for 3 days. with no response to supportive therapy and died. The incidence found in this study was 2.25% (2 out of 89)

Right lower lobe atelectasis developed in one patient with coronary arteries revascularization during the first 24 h postoperative and resolved by physiotherapy. Mechanical ventilation for 7 days was required in another patient with congenital heart disease and deteriorated further to death after lower lobe inflation guided by repeated endotracheal intubations. The incidence of early postoperative atelectasis was 2.25% (2 of 89).

Right lower lobe pneumonia occurred in one patient with CABG surgery in elderly age, one patient with mitral valve replacement, and another patient with congenital heart disease, they presented with fever, leucocytosis, tachypnea, hypoxemia, and right lower lung zone heterogeneous opacity, the causative organisms were Klebsiella spp. And streptococcal pneumonia,

respectively. However its very unfortunate to mention that the poor girl of 4 years of age of VSD died in 4th post operative day due to pneumonia with high fever from gm negative bacteria Pseudomonas aeruginosa resistant to all antibiotics including meropenem with concomitant wound dehiscence and mediastinitis .The incidence of pneumonias in early postoperative period was 3.37% (3 of 89).The total incidence of early postoperative pulmonary complications after open heart surgery was 16.85% (15 of 89), while the incidence of mortality was 5.62% (5 of 89).

A total of three patients one being 45 years old in CABG surgery one patient of 30 years old with AVR and one patient of Incomplete AV canal defect developed post operative pneumothorax on early post operative days and recovered after tube thoracotomy who had finding of intact pleura on per operative aspect on that side without any chest drain tube insitu. The incidence was 3.37% (3 out of 89)

Finally, five patients developed pleural effusion in late post operative period on left side in late postoperative period after discharge on subsequent follow up. The incidence was 5.62% (5 out of 89)

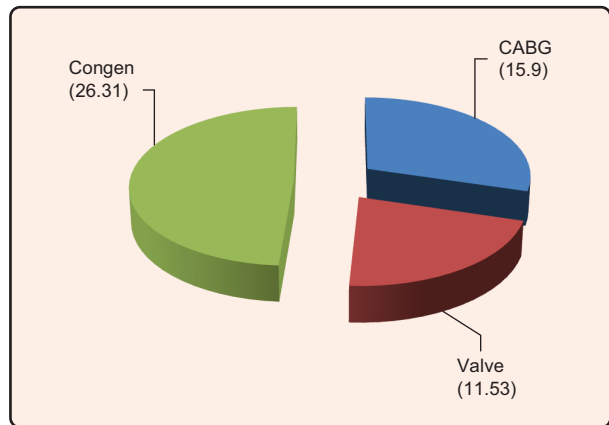


Fig.-1: Percentage of PPC in CABG, Valve and Congenital cases

Table-I
showing different types of PPC and Outcome

| | A | R | DS | Ate | lec | tasis | Pne | umo | thorax | PL | EF | | P | N | M |
|--------|-----|-----|---------|-----|-----|---------|-----|-----|---------|-----|-----|---|---------|---|---|
| | Age | Sex | Outcome | Age | Sex | Outcome | Age | sex | outcome | Age | sex | | outcome | A | S |
| CABG | 60 | M | Died | 50 | M | S | 45 | M | S | 55 | F | S | 65 | M | D |
| Valve | | | | | | | 30 | F | S | 39 | M | S | 37 | F | S |
| Congen | 03 | F | Died | 04 | M | Died | 06 | M | S | 08 | M | S | 04 | F | D |
| Total | | 2 | | | 2 | | | 3 | | | 5 | | | 3 | |

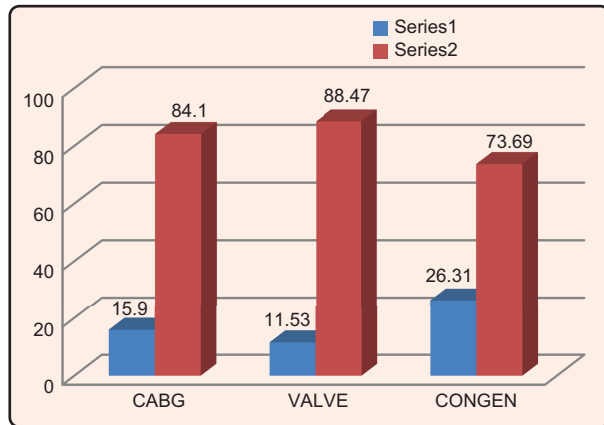


Fig.-2: Percentage of PPC and without PPC

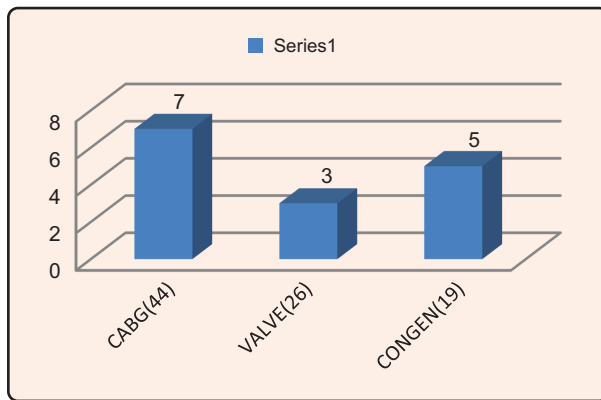


Fig.-3: number of PPC

Discussion:

Pulmonary complications are less after cardiopulmonary bypass but can be life threatening in some cases. The documented incidence of PPCs ranges from 3% to 16% after CABG and 5%-7% after valvular heart surgery and 6-76% after congenital heart surgery. 3

The aim of this study was to measure the incidence of pulmonary complication after open heart surgery, 89 patients (65 males and 24 females) were included for this study, open heart surgery was done using Cardiopulmonary bypass (CBP) in all 89 patients . It should come as no surprise that cardiac surgery can have pronounced effects on lung function. The anesthetic agents, chest wall alteration, and direct lung manipulation can all affect pulmonary parameters. Functional residual capacity (FRC) can decrease by up to 20% with anesthesia (Szelowski LA, et al. Curr Probl Surg. 2015;52[1]:531), and the thoracic manipulation and alteration of rib cage mechanics with a classic median

sternotomy approach can lead to decreases in forced vital capacity (FVC) and expiratory volume in the first second of forced expiration (FEV1) that can last for months after surgery. Use of the cardiopulmonary bypass circuit can also lead to bronchoconstriction.4

The most frequent pulmonary consequence of cardiac surgery is atelectasis, seen on postoperative chest radiographs in approximately 50% to 90% of patients (Szelowski LA, et al. Curr Probl Surg. 2015;52[1]:531). In our study the incidence was found in atelectasis was 2.25%. in another study in Pakistan it was found 3.86% (Naveed A et al.2017) Incidence of atelectasis in our study was comparable to this study. The reduction in incidence of atelectasis in our study may be due to the practice of pre-operative incentive spirometry practice in all patients before surgery and the use of positive end expiratory pressure (7-8 cmH2O) during mechanical ventilation after surgery. Induction, apnea during cardiopulmonary bypass, manual compression of the lungs for surgical exposure, internal mammary harvesting, and pleurotomy can lead to atelectasis in the intraoperative setting while weak cough, poor inspiratory efforts, interstitial edema, and immobility further contribute postoperatively (Weissman 2004). While frequently seen, clinically significant pulmonary consequences from this radiographic finding alone are rare (Weissman 2004).4

Pleural effusions are seen on immediate postoperative chest radiographs in the majority of patients. Additionally, 10% to 40% of patients develop pleural effusions 2 to 3 weeks after surgery secondary to postpericardiotomy syndrome. In our study pleural effusion was noted as late PPC, the incidence of which is 5.62%. While some effusions require drainage and further intervention (eg, hemothorax), most effusions require no specific treatment and resolve over time (Weissman 2004).4

The prevalence of pneumonia following cardiac surgery varies based on differences in study populations and diagnostic criteria, but it remains an important source of morbidity and mortality. In our study, the incidence of pneumonias in early postoperative period was 3.37% In one series, postoperative pneumonia occurred in 3.1% of patients, with higher rates observed in patients who were older, had worse left ventricular ejection fraction, had COPD, experienced longer bypass times, and received more red blood cell transfusions in the operating room (Allou N, et al. Crit Care Med. 2014;42[5]:1150). This is very much compatible with findings of our study. A meta-analysis found that an average of 6.37% of patients developed ventilator-associated pneumonia (VAP), and

this rose to 35.2% in those receiving ventilation for greater than 48 hours. Those who developed VAP had an odds ratio of dying of 15.18 (95% CI 5.81-39.68) compared with those who did not (He S, et al. *J Thorac Cardiovasc Surg.* 2014;148[6]:3148).4

A small proportion of patients go on to develop ARDS. While relatively uncommon, ARDS carries a high mortality rate. In our study ARDS incidence was found 2.25% with high mortality. Many possible etiologies for ARDS in cardiac surgery patients have been proposed, including an inflammatory response related to the cardiopulmonary bypass circuit, reperfusion injury secondary to reduced pulmonary blood flow during bypass, protamine administration, transfusion, hypothermia, and lack of ventilation during bypass (Weissman 2004); (Stephens RS, et al. *Ann Thorac Surg.* 2013;95[3]:1122). Type of surgery may also play a role, as patients who undergo aortic surgery are at an even greater risk (Stephens 2013). As with other cases of ARDS, treatment is supportive: low tidal volume ventilation and careful management of fluid balance, as well as paralysis, prone positioning, and consideration for extracorporeal membrane oxygenation (ECMO), as appropriate (Stephens 2013).4

Conclusion:

The cumulative incidence of pulmonary complication after open heart surgery was 16.85%, with an overall mortality 33.33% (5 of 15) and mortality among all patients was 5.62% (5 of 89). ARDS occurred in 2.25%, pneumonia

occurred in 2.79% atelectasis occurred in 3.37%, pleural effusion occurred in 3.37%.

References:

1. Post Operative Pulmonary Complications Following Surgery for Congenital Heart Disease MNA HASAN, M SHARIFUZZAMAN, AK SHAMSUDDIN, SK BISWAS, J HOSSAIN, MRA SHEIKH et.al *J Bangladesh Coll Phys Surg* 2017; 35: 52-60
2. Incidence and outcome of pulmonary complications after open cardiac surgery, Thowra Hospital, Cardiac center, Sana'a, Yemen Faker Ali Ahmed Al-Qubati , Abdulkarim Damag , Tarek Noman et.al 0422-7638 @ 2013 Production and hosting by Elsevier B.V. on behalf of The Egyptian Society of Chest Diseases and Tuberculosis. <http://dx.doi.org/10.1016/j.ejcdt.2013.08.008> Open access under CC BY-NC-ND license.
3. Incidence and risk factors of Pulmonary Complications after Cardiopulmonary bypass Anjum Naveed, Hammad Azam, Humayoun Ghulam Murtaza, Rana Altaf Ahmad, Mirza Ahmad Raza Baig et.al *Pak J Med Sci.* 2017;33(4):993-996. doi: <https://doi.org/10.12669/pjms.334.12846>
4. Postoperative pulmonary complications of cardiac surgery by Christopher Noel, MD. available in <https://www.mdedge.com/chestphysician/article/158060/pulmonology/postoperative-pulmonary-complications-cardiac-surgery>; February 6, 2018